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ABSTRACT

Research in science teacher education does not appear to have made very much difference in the ways preservice and inservice science teacher education is conducted or in the ways participating teachers teach. This paper illustrates and suggests possible explanations for this state of affairs, and indicates research alternatives which seem to hold greater promise for improving practice. Examples of contemporary science teacher education research are presented, asking of each how significant the question is and to what extent the results achieved may be expected to improve science teacher education practices. It appears that the potential influence of the research is, in many cases, unduly restricted by the format of the research and by the implied assumptions about how science teachers and science teacher educators evaluate proposals for the improvement of practice. Alternatives to the most familiar form of science teacher education research are presented, looking at the significance of the questions and the potential influence of the results. (Author/BB)

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SECOND THOUGHTS ABOUT THE POTENTIAL INFLUENCE OF SCIENCE TEACHER EDUCATION RESEARCH

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Introduction

Perusal of the summary of science education research for the year 1975 (Mallinson, 1977) indicates that the "scientific" paradigm continues as the dominant approach to research. Although I do not wish to attribute motives to researchers, many studies give the impression that their fundamental concern is to preserve the scientific quality of the research. In this paper I argue that limiting our research to the scientific paradigm can restrict the significance of our research questions and the potential influence of the results we obtain.

Power (1976) suggests that we need to consider the potential which each of several research paradigms can bring to our most significant problems in science education. His analysis of papers presented at two science education conferences in 1974 identified an "anthropological" paradigm and a "philosophical" paradigm as alternatives to the dominant "agricultural-scientific" paradigm. I agree with Power's suggestion, despite my personal commitment to the philosophical paradigm (Roberts and Russell, 1975). My criticisms in this paper are not directed at the scientific paradigm itself but at its excessive or exclusive application.

The scientific paradigm has the appeal of apparent objectivity, the confidence of statistical analysis, and the comfort of quantitative measurement. More than these, however, it has the strength of tradition. Most science educators have been trained in its use, and in turn they train others to do research in the same way. A research role learned by modeling is deeply rooted and often encouraged by similarly trained editorial staffs. By its very success, however, such a strong research paradigm loses some of its ability to be self-critical

and runs an increasing risk of being perpetuated for its own sake rather than for its power, scope, and influence on practice. We in science education may be doubly tied to the scientific paradigm by our own training in and positive attitudes toward science.

I have selected a focus on science teacher education research because it is in this domain that research results have implications for the teaching practices of researchers and their university-level colleagues, rather than for science teachers in elementary and secondary classrooms. If we are not influenced by our own results, it is unlikely that those who do not do research will be influenced. Also, it is only too easy to assume, erroneously, that change occurs more quickly and easily in the university than in the public schools (Sarason, 1971).

An Example of Research in the Scientific Paradigm

My criticism of research in the scientific paradigm is based on its apparent neglect of the realities of influencing educational practices, in the rush to ensure soundness of statistical design and treatment. I wish to call attention to two specific aspects of this neglect.

1. If the choice of a research paradigm precedes the selection of a topic for investigation, one is likely to select a question not for its significance but for its being "researchable" in a particular way. The scientific paradigm does not seem to lend itself to the earliest stages of research into significant questions.

2. When the scientific paradigm is followed exclusively, results are obtained in a form which is not likely to influence current educational practices.

To illustrate my points that ensuring the scientific quality of one's research is no guarantee of significance or

of influence on practice, I have selected for detailed discussion one study from the teacher education section of Mallinson's (1977) summary of science education research in 1975. It should be clearly understood that I intend no criticisms of the study itself, which was one of the few to find its way into the pages of the Journal of Research in Science Teaching. Rather, the study is chosen as an excellent example of the scientific paradigm applied to science teacher education.

Assume, for the moment, that you teach a biology course for prospective elementary school teachers. How would you respond to research findings that an "outdoor" (rather than an "indoor") laboratory increases student understanding of science as process and of social aspects of science, and also their understanding of "selected appropriate biological principles?" Would you modify your course by setting up an outdoor laboratory?

Probably not without more information, assuming you are willing to consider changing your present practices. The particular findings I have described were obtained by William Chrouser. Your reading of his paper would tell you which tests he used to measure understanding of process and social aspects of science, and biological principles; it would also show you how he analyzed the data (Chrouser, 1975). Having satisfied yourself that the testing and statistics are in order, are you ready to design an outdoor laboratory?

Like many reports of science teacher education research of this type, no details are given about either the outdoor or indoor laboratory activities. Chrouser reports that students in both laboratories attended the same lectures, and that the two laboratories met at the same time and dealt with the same principle or series of principles (p. 43). His section on conclusions does provide some contextual details, reported as

"subjective behaviors which were observed which were not measured" (p. 46). Enthusiasm, satisfaction with school, and group loyalty and unity were all noticeably greater for students in the outdoor laboratory. Yet Chrouser does not comment on how students in the indoor laboratory, who must have noticed the "subjective" qualities shown by the outdoor group, reacted to their indoor placement.

What is your inclination now, as the hypothetical instructor of such a biology course? Although specific details are not provided about the outdoor laboratory, you note that a number of references on outdoor work are given. Assuming that you would like to proceed with a change to an outdoor laboratory, what is your most likely reason for wanting to do so?

1. To enable students to achieve the reported gains in understanding of process and social aspects of science.

2. To achieve the subjective qualities of enthusiasm, school satisfaction, and group loyalty and unity.

3. To model the use of the outdoor laboratory to your students.

I doubt that the first response alone would be seen by many as sufficient reason for change, although the gains in understanding are the results supported by the study. When I say this, I imply no criticism of the testing procedure, data analysis, or conclusions. My attention is directed primarily to the fact that Chrouser has established no clear conceptual links between use of an outdoor laboratory and various aspects of increased student understanding. This is my criticism, and its object is not the investigator but the research method applied to the initial question. The scientific paradigm can provide evidence for the existence of relationships but little insight into the nature of those relationships.

In the introduction of his paper, Chrouser discusses his interest in the indoor-outdoor laboratory comparison; in his section on implications, he attempts to rationalize his significant findings. But this very familiar research paradigm in science education does not deal with data which could explain the findings. Chrouser set out to compare two laboratory settings, and he selected four test instruments to generate data for the comparison. His enthusiasm for the outdoor setting is clear, but his introduction gives no reasons for expecting significantly higher scores on the four tests he used: "Test on the Social Aspects of Science," "Methods and Procedures of Science: An Examination," "Watson-Glaser Critical Thinking Appraisal," and "Understanding of Selected Biological Principles: An Examination."

One could assume that these were four convenient instruments measuring different aspects of potential student response to different laboratory settings. The account of the study does not explain why these tests were considered appropriate as criteria of comparison. The limitation imposed by the research paradigm, not by the investigator, is most apparent in Chrouser's comment on his "no significant difference" result with respect to critical thinking: "It may be implied from this study that critical thinking ability is not adversely affected by the use of the out-of-doors as a laboratory" (p. 47). The wording could suggest that an adverse effect was expected but, happily, not found. In fact, I would suggest, the procedure of confronting two methods with a set of tests without good reason to expect significant differences leads us to use such wording when no significant differences are found, just as we attempt after-the-fact rationalizations of the significant differences we do obtain by this method.

To sum up, the use of the scientific paradigm to compare indoor and outdoor laboratories is not justified in

the paper, and its appropriateness to the question seems to be assumed. Chrouser sets out to investigate whether the outdoor laboratory is more effective than the indoor, but he is not particular about the criteria of effectiveness. He also leaves a reader to assume that the tests used do actually measure what their titles claim to measure. There is good reason, I suggest, to attribute these characteristics of the study and report not to the investigator but to the chosen research paradigm. At the conclusion of the study, the paradigm leaves the researcher without data relevant to explaining the effects he has detected. Chrouser does go so far as to include some qualitative differences, but he labels these "subjective" and neglects them in favor of "objective" differences in test score averages between the two experimental groups.

When studies such as this receive the stamp of publication in a refereed journal, I find it hard not to believe that the methodological tail is wagging the dog of science teacher education research. The question posed hardly seems of major significance, and the results seem unlikely to change the conduct of science teacher education beyond the settings where Chrouser and others personally committed to an outdoor laboratory work. The "objective" results, which go unexplained, seem less influential than the "subjective" differences, which are at least intuitively appealing and understandable. Personal convictions about the value of an outdoor laboratory may well be the strongest element in decisions to teach in that fashion.

Research Paradigms Imply Theories of Change

Although typically unarticulated and unrecognized as such, every research paradigm contains a theory of change. We are all familiar with the theory implicit in the scientific

paradigm: Two means to the same end are compared and the more effective means is taken as the appropriate one for future work. The practitioner working to a particular end is expected to bring practice into agreement with research findings, recognizing their logical force.

This theory of change may be viable when comparing corn hybrids, fertilizers, and the like, although I expect a farmer also develops preferences which influence willingness to change established practices. In our science classrooms, however, there seems little doubt about the efficacy of the same attitude to change: practices are not changed by the logical force of research findings. Although we have not subjected science teacher education activities to the same scrutiny as science classrooms, there is little reason to expect research findings to have any greater influence on existing practices in science teacher education.

The increasingly sophisticated literature on curriculum implementation, particularly of the case study variety, tells us that scores of well-meaning attempts to improve school learning experiences have failed to affect significant changes in the traditions of teaching practice. Science classrooms have not been exceptions to this rule, although, among curriculum developers, science educators may have been the most optimistic about the use of logic to influence practice. McKinney and Westbury (1975) have documented one school system's decision to abandon PSSC in a manner which helps us to understand why logic is not enough. Sarason (1971) has noted the tendency for change to stop at the level of replacing one textbook with another (a new "means"), an exercise which is itself sufficiently challenging to obscure the ultimate purposes of the change. Of course, new curricula are not "results" obtained by scientific research, but they do at least represent "means" which have gained entrance to classrooms.

The attitude that logical force of findings can produce change is a popular one, largely associated with the scientific research paradigm. For example, near the end of their monumental collection of research related to teaching, Dunkin and Biddle (1974) present a summary of findings for the interested teacher and discuss five "concerns" to be satisfied by research before action is taken in schools on the basis of research results. They suggest that research must demonstrate (1) meaningful concepts, measured with valid and reliable instruments; (2) valid, uncontaminated research designs; (3) a strong, independent effect; (4) application of an effect over a wide range of teaching contexts; and (5) explanation of the effect (Dunkin and Biddle, 1974, pp. 358-360). I have already noted, and Chrouser's study has illustrated, the difficulty of building explanations from data generated in the scientific paradigm. Of the fifth concern, Dunkin and Biddle plausibly assert that "findings from research become believable to the extent that they are imbedded within explanatory theories." (p. 360) They go on to point out that most positive results of research have not been "integrated into empirically based theories of teaching." (p. 360)

Notice how exclusively logical are the concerns which Dunkin and Biddle list. Apparently, action on the basis of research findings would proceed if the five concerns have been satisfied, or discussion about how to change would follow a decision to act upon rather than to ignore the findings. The concerns listed by Dunkin and Biddle are rather clearly located within the assumptions of the scientific paradigm.

Doyle and Ponder (1977) have quite nicely challenged this popular view of the teacher as a "rational adopter." (When change does not proceed according to logic, a second popular view arises, of the teacher as "stone-age obstructionist.") From analysis of descriptive data about innovation

projects, Doyle and Ponder have constructed a third image of the teacher as "pragmatic skeptic," evaluating change proposals according to a "practicality ethic:" What does the teacher perceive to be the "potential consequences of attempting to implement a change proposal in the classroom?" (Doyle and Ponder, 1977, p. 6) They suggest three general criteria for assessing the practicality of a claim about ways of behaving in classrooms:

1. Instrumentality (Does the proposal have "instrumental" content, in contrast to statements of principle or valued objectives?)

2. Congruence (How well does the proposal "match" teachers' perceptions of their classroom situations?)

3. Cost (How easily can the change be made, and what benefits does it promise?) (Doyle and Ponder, 1977, pp. 7-9)

Greater attention to these issues, it is suggested, could generate changes more likely to influence what happens in classrooms.

Doyle and Ponder may have taken a useful step toward alleviating what Sarason (1971) sees as the source of frustration in dealing with change: "That reality stubbornly refuses to conform to our theories and categories of thought is what has caused so much grief." (p. 21) The practicality ethic is a new way of viewing the problem of influencing practice. However, Sarason goes beyond the idea of making new means more acceptable or attractive to teachers by suggesting that our linguistic distinction between means and ends prevents us from seeing that changing to achieve our objectives is a continuous process. (pp. 9 and 12) Sarason's particular contribution to understanding the difficulty of change has included analysis of the "culture" of the school, and he stresses the importance of recognizing

that individuals act within highly complex social settings. Sarason offers the following as four requirements of a general theory of change.

1. A theory of change must "be appropriate to, and mirror the complexities of, social settings." (p. 58)

2. Introducing an important change "does not and cannot have the same significance for different groupings comprising the setting," with the result that some groups will oppose the change. Ignoring such opposition severely jeopardizes chances of success. (p. 59)

3. As decisions taken affect more groups within the setting, representativeness within the decision-making group is, in itself, no guarantee of success. (p. 59)

4. Every proposal for change implies a time perspective, and frequently the time needed to achieve the goals is severely underestimated. (p. 60)

I cite these analyses by Doyle and Ponder and by Sarason to indicate the extent to which the scientific research paradigm lacks ingredients appropriate to achieving an influence on practice. When one works exclusively within that paradigm, one is likely to be handicapped by inadequate images not only of teachers (as rational adopters rather than pragmatic skeptics) but also of the school or university settings in which they work (seeing them as collections of independent decision-makers rather than as complex arrays of groupings of individuals). Alternatives to the scientific research paradigm can be viewed in part as ways of conducting research with more explicit and more sophisticated (though still imperfect) theories of change.

Examples of Research in other Paradigms

The alternate paradigms cited by Power represent important moves in the direction of obtaining data and theoretical perspectives which could improve the influence of

research on practice. The anthropological paradigm can generate data about what is presently happening in classrooms and schools, whether change is or is not being attempted. (See Parlett and Hamilton, 1977, for further discussion of this paradigm.) The anthropological research paradigm is particularly useful for identifying teachers' and students' perceptions of classroom events, and the interaction and influence of those perceptions. The philosophical paradigm can generate systematic theoretical perspectives for the analysis of present practices, to identify specific elements of practice where modification is appropriate, and to determine what types of changes are appropriate. (See Roberts, 1977, for further discussion of this paradigm, and Russell, 1977, for discussion of practical issues involved in joining researchers and teachers in the use of philosophical analysis of science education practice.)

To complete this set of reflections of the potential influence of science teacher education research, I discuss several studies which illustrate the promise of alternative research paradigms. I begin with the Ford Teaching Project, directed by Elliott and Adelman, because it illustrates so clearly the manner in which the three research paradigms--scientific, philosophical, and anthropological--could be combined to enhance the influence of research on practice (and, simultaneously, of practice on research).

The Ford Teaching Project

The central focus of the Ford Teaching Project, in England, was the implementation of "inquiry/discovery" approaches in classrooms. "Action research" was the basic approach, although "participant observation" played a significant part; both are techniques within the anthropological paradigm. The project was continuously concerned with

classroom events, influence on practice was part of the research rather than something to follow, and active involvement of teachers was an essential element (hence, "action research"). Elliott (1976) reports the attention which was given to teachers' ideas and behavior, and the direct relationship seen between teacher behavior and the influence of research.

> The fundamental problem of curriculum reform lies in the clash between the theories of the reformers and those implicit, often unconsciously, in the practice of teachers. Reformers fail to realize that fundamental changes in classroom practice can be brought about only if teachers become conscious of the latter theories and are able to reflect critically about them. (Elliott, 1976, p. 2)

Without going further into the details (readily available in Elliott's paper) of the Ford Teaching Project, I wish to call attention to several features of its products and findings.

1. At the conclusion of the project, a set of twenty-one booklets were produced, in four categories: Patterns of Teaching, Research Methods, Hypotheses, and Teacher Case Studies. Virtually all of the booklets include contextual data in the form of classroom transcripts or conversation about classroom events by teachers and/or pupils.

2. From several different points of view, the researchers (teachers and central team) generated "hypotheses" about how teacher behavior may have to change in order to practice an "inquiry/discovery" approach.

3. Elliott's paper closes with a list of forty-three "hypotheses" about the development of "self-monitoring" ability by teachers. (Elliott, 1976, pp. 18-21)

This project's generation of hypotheses as research results, rather than as starting points as in the scientific paradigm, is particularly noteworthy. It would be quite

appropriate to investigate "scientifically" the hypotheses emerging from the Ford Teaching Project. Here, then, is an illustration of the possibility of using one research paradigm to generate starting points for the application of a second. I hope this illustration makes it clear that I am not suggesting, in this paper, that the scientific paradigm intrinsically lacks the power to generate results of potential influence on practice. However, it may well be the case that an alternative paradigm must be used to generate hypotheses of significance, with a contextual base rich enough to guide the considerations suggested by Sarason and by Doyle and Ponder as relevant to influencing practice.

Other examples

Gaskell (1975, 1976) has used the method of "participant observation" to make an important contribution to the study of teacher education practices. He studied the progression of perspectives dominant in student teachers over the course of a teacher education program which attempted to encourage an "analytic perspective" on teaching (similar to Elliott's notion of "self-monitoring"). Gaskell's data indicate that it is indeed possible to develop such a perspective in a preservice program. He has also documented the difficulties of developing and maintaining an analytic perspective in settings which, however unintentionally, discourage or fail to encourage such an attitude toward teaching. (Gaskell, 1975, 1977)

Personally, I have had the opportunity to be involved in research guided by the anthropological and the philosophical paradigms, some general to teacher education and some specific to the education of science teachers. Within the philosophical paradigm, I developed an analytical scheme for assessing the provision made by science teacher education for the development

of teachers' views of the nature of science and the nature of teaching (Russell, 1976). It will not surprise science educators that application of the scheme to a sample of science methods textbooks found those written materials largely lacking in making provision for the development of views of science and teaching. The value of the scheme is that it enables one to make such an analysis of materials and instructional events within science teacher education.

In the Ottawa Valley Teaching Project, the staff of a university field centre worked with teachers on an in-service basis to link a technique for analyzing one's own teaching (pattern analysis) with the broad goal of change in the direction of achieving affective and higher-order cognitive objectives. This research was located primarily within the anthropological paradigm. One of the most interesting features of the final report (Ireland and Russell, 1977) is a list, illustrated with classroom transcripts, of patterns of teaching behavior which participating teachers identified as hindering the achievement of their objectives.

It is interesting to note that the three anthropological studies just cited contain the common element of enhancing teachers' abilities to reflect systematically on their own behavior. One wonders how the scientific paradigm could be used productively at the outset of research in which this element is predominant. Increasing one's awareness of one's own teaching behavior and of its potential and actual effects on students seems only too obvious a starting point for deliberation about and actual attempts to use alternative practices. This approach seems equally applicable to science teacher education, as a prelude to the formulation of significant research issues and hypotheses which could be investigated within the scientific paradigm.

Concluding Remarks

Alternatives to the scientific paradigm are attracting increasing attention in educational research, and within science education. (Power, 1976) The discussion in this paper has focused on the potential influence of research results, with special reference to science teacher education research.

Case studies of curriculum implementation, documenting the ideals which were not achieved by the new curricula of the 1960s, seem to have lent support to alternatives to traditional research designs which first and foremost seek to be scientific. Influencing educational practices is, we now realize, a highly subjective process not easily influenced by strictly objective results. Science teacher educators doing research within the scientific paradigm may find it even more difficult than science teachers to modify their teaching behavior in response to research findings.

There are interesting parallels between the "failure" of new curricular designs to influence classroom practices and the "failure" of "scientific" educational research to influence those same practices. Reid (1975) traces part of the "curriculum" problem to the assumption that curriculum design and curriculum implementation can be separated. Science teacher education research within the scientific paradigm makes a comparable assumption that research findings can be separated from their application to modify current practices. I have suggested that a research paradigm must consider the theory of change implied by its investigating and reporting procedures, just as curriculum development must include strategies for achieving its purposes in terms of changed classroom events.

The examples which have been provided are but a very small selection from the broad range of alternative research activities now taking place within education, though perhaps not as commonly in science education. The examples do illustrate the possibility of increasing the potential influence of scientific research by bringing in elements other than the logic required to achieve change. Given the present state of the art, this may be most easily accomplished by stepping out of the scientific research paradigm, using alternative paradigms to generate hypotheses whose significance is both theoretical and practical.

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